Artificial intelligence and tourism innovation as a lever for developing sustainable ecotourism: An analytical study of leading international experiences

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Abstract---This study aimed to demonstrate the role of tourism innovation and artificial intelligence applications in supporting and enhancing sustainable ecotourism, through the use of the descriptive-analytical method. The study concluded that the Emirati and Spanish experiences have succeeded and proved effective in employing smart technologies to manage ecotourism destinations through monitoring systems based on artificial intelligence. The United Arab Emirates focused on creating interactive applications to raise visitors' awareness of responsible environmental behavior. Spain, on the other hand, was distinguished by integrating tourism innovation into green transition projects through the development of digital platforms to distribute tourists and reduce environmental pressure on sensitive areas. These experiences confirm that artificial intelligence represents a strategic tool for developing ecotourism by improving efficiency, rationalizing resource use, and enhancing the tourist experience in a manner that supports sustainable development.

Keywords---Artificial Intelligence, Tourism Innovation, Ecotourism, Sustainable Tourism Development.

Introduction

Tourism is no longer merely a traditional recreational activity; rather, it has become a complex industry intersecting with economic, social, cultural, and environmental dimensions. With the emergence of global challenges related to climate change and resource depletion, sustainability in tourism has become an indispensable strategic option. Among the forms of sustainable tourism, ecotourism stands out as a model that combines environmental conservation with achieving economic benefits for local communities. However, activating this model remains dependent on the ability of entrepreneurs to innovate responsible projects, within an institutional and economic environment that may not always provide the required support.

Accordingly, this paper seeks to answer a central question: What are the main requirements and major difficulties facing entrepreneurship in sustainable ecotourism? To answer this question, a theoretical grounding of the concept of tourism and its importance is first presented, followed by addressing the sustainable development approach and its dimensions, then focusing on sustainable tourism development. Finally, the role of green entrepreneurship in enhancing ecotourism is analyzed, highlighting challenges and prospects.

Research Problem:
Despite the growing global interest in ecotourism as a sustainable development option, applications of artificial intelligence and tourism innovation in this field remain uneven among countries in terms of the degree of integration between technology and environmental protection. Accordingly, the research problem of this study revolves around the following main question:
To what extent do tourism innovation and artificial intelligence applications contribute to enhancing and developing sustainable ecotourism?

Research Hypotheses:
The research is based on the following main hypothesis:
- The employment of artificial intelligence and tourism innovation has effectively contributed to the development of ecotourism by improving operational efficiency, rationalizing natural resources, and enhancing the tourist experience, thereby supporting the achievement of sustainable development.

Importance of the Research:
This study is of great importance as it seeks to shed light on leading international experiences in the field of ecotourism, focusing on the experiences of the United Arab Emirates and Spain as two advanced models in integrating artificial intelligence and tourism innovation within sustainable development strategies. The importance of the study lies in providing an analytical vision that benefits decision-makers, researchers, and actors in the tourism sector in developing countries, especially those seeking to achieve a balance between tourism growth and the preservation of environmental resources.

Research Objectives:
This study seeks to achieve the following objectives:

- Providing a theoretical grounding for tourism and ecotourism;
- Highlighting the ability of artificial intelligence applications to shift paradigms in the field of ecotourism;
- Shedding light on leading international experiences in the field of ecotourism.

Methodology and Tools:
Within the framework of analyzing and addressing the research problem and with the aim of testing the proposed hypotheses, the descriptive method was used, which is appropriate to the nature of the topic through various definitions and basic concepts related to the subject of the study, as well as the analytical approach, which was employed to deepen understanding of the study's axes and to derive results.

2. The Conceptual Framework of Ecotourism and Sustainable Development:
Definitions of tourism have varied according to different approaches. While the World Tourism Organization views it as an activity undertaken by individuals outside their usual environment for various purposes, some researchers view it as an economic, social, and cultural system that contributes to resource development and the exchange of values among peoples. The importance of tourism lies in its role as a job-generating sector and a stimulus for investment in infrastructure, in addition to its role in enhancing cultural openness. Tourism marketing also represents a fundamental pillar for the success of destinations, as it is based on multiple strategies that include building a tourism identity, using digital technologies, and employing media in promoting tourist destinations (Al-Shahid & Tammah, 2024, p. 589).

2.1. The Historical Development of the Concept of Ecotourism:
The concept of ecotourism has developed through several stages, starting from protecting tourists from pollution, passing through rationalizing resources and reducing waste, and culminating in achieving a sustainable balance between tourism activity and ecosystems. This development reflects the rising global awareness of the importance of environmental conservation within tourism practices.
- **Stage of Protecting Tourists from Pollution:**
The early beginnings of the concept of ecotourism were associated with focusing on protecting tourists from surrounding pollutants rather than direct concern for the ecosystem itself. Efforts were concentrated on creating healthy and safe tourist spaces away from sources of air, water, and noise pollution, ensuring tourist comfort and preserving their health. This approach represented a limited preventive orientation, but it constituted the first building block in the emergence of awareness of the need to link tourism activity with the surrounding environment (Vasja, Danijel, Maja, & Vedran, 2021, p. 2).
- **Stage of Halting Environmental Waste:**
With the escalation of global discussions on the dangers of environmental degradation during the 1970s and 1980s, the concept of ecotourism evolved to include a broader dimension represented by reducing environmental waste. At this stage, attention was directed toward rationalizing the consumption of natural resources such as water and energy, and reducing waste and pollution resulting from tourism activities. Thus, the concept moved beyond protecting tourists to

emphasizing the responsibility of tourism actors in preserving natural resources and ensuring their sustainability (Al-Shammari, 2018, p. 69).

- **Stage of Dealing with Existing Environmental Conditions:**

This stage represents maturity in the development of ecotourism, as the objective was no longer limited to reducing damage or waste, but rather to establishing a balanced relationship between tourism activity and ecosystems. New approaches emerged that called for involving local communities in benefiting from tourism projects, raising tourists' awareness of the importance of environmental conservation, and adopting strategies that make tourism an effective tool for achieving sustainable development (Honey, 2008, p. 82).

2.2. The Concept of Ecotourism and Its Components:

First: The Concept of Ecotourism

Ecotourism has been defined as one of the forms of sustainable tourism that focuses on visiting natural areas with high environmental sensitivity, while adhering to principles of environmental conservation and providing economic and social benefits to local communities. Academic definitions of this concept have varied: some consider it "responsible travel to natural areas that contributes to environmental protection and enhances the well-being of local populations," while the International Union for Conservation of Nature (IUCN) defines it as "tourism based on the natural and cultural resources of tourist destinations, aiming to minimize negative impacts and achieve an educational and recreational experience for the tourist."

It has also been noted that ecotourism aims to enhance environmental awareness among tourists and encourage them to adopt responsible behaviors during visits, while others emphasize that this type of tourism integrates economic development for local communities with the preservation of biodiversity.

Accordingly, ecotourism is based on three interrelated pillars: environmental protection, valorization of natural and cultural resources, and involving local communities in direct benefits, with a focus on creating a balance between tourism development objectives and environmental sustainability (Al-Zahrani, 2020, p. 36).

Second: Distinctive Characteristics of Ecotourism

Ecotourism is concerned with studying tourism patterns that consider environmental, social, and economic dimensions, with a focus on protecting nature and enhancing community participation. It includes a set of characteristics and components that ensure the sustainability of natural and cultural resources and the achievement of a responsible tourism experience, among which are:

- Connection to natural areas: it relies on natural assets such as reserves, forests, coasts, and deserts, giving it an authentic, non-artificial character.
- Focus on sustainability: it seeks to ensure the continuity of environmental resources and prevent their depletion through rational and prudent use (Ceballos-Lascuráin, 1996, p. 92).
- Environmental and social responsibility: tourists and tourism actors bear the duty of reducing negative impacts and protecting ecosystems.

- Educational and awareness dimension: it is not limited to recreation but seeks to raise tourists' awareness of environmental issues and promote values of nature conservation.
- Involvement of the local community: which enhances employment opportunities, combats marginalization, and increases residents' acceptance of tourism projects (Gössling, Scott, & Hall, 2015, p. 132).

Third: Basic Components of Ecotourism
Ecotourism has an integrated structure consisting of interconnected components, including (Weaver, 2008, p. 69):
- Natural assets: such as forests, mountains, deserts, beaches, and water resources, which constitute the primary pillar of the ecotourism product.
- Cultural and heritage resources: traditional practices, folk arts, and architectural patterns form an integral part of the ecological experience.
- Appropriate infrastructure: including eco-transport (bicycles, natural trails), eco-friendly accommodation, and waste management.
- Legislative and regulatory frameworks: such as laws related to protected areas, environmental standards, and monitoring of tourism activities to limit negative impacts.
- Human element: whether tourists who adopt responsible behavior, local communities involved in providing sustainable tourism services, or public and private actors who organize the activity.

Accordingly, ecotourism is not merely a limited recreational activity, but an integrated system based on sustainability principles, requiring integration between environmental, economic, social, and cultural dimensions.

3. Theoretical Grounding of Sustainable Development and Its Dimensions:
The concept of sustainable development has become a fundamental pillar in contemporary development thought, as it first highlighted the deep interconnection between economic, environmental, and social dimensions. The report defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs," a definition that integrates intergenerational justice from an ethical perspective and rational resource use from a practical perspective. Over the decades, this concept has evolved into a reference framework for international policies, translated into landmark milestones such as the Rio Conference 1992, the Earth Summit 2002, and the United Nations 2030 Agenda for Sustainable Development.

In this context, sustainable tourism has emerged as one of the vital applications of sustainable development, as it is a multidimensional sector that brings together economy, culture, and environment. It is not limited to developing tourism activities alone, but seeks to achieve a balance that ensures the preservation of natural resources, promotes social justice, and guarantees the continuity of economic benefits for future generations. Hence, understanding sustainable tourism requires an in-depth examination of its main dimensions that constitute the conceptual and practical framework for its realization (Abu Zaid, 2017, p. 88).

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First: Dimensions of Sustainable Development
Sustainable development dimensions can be analyzed as follows:

- **Economic dimension:** The economy represents a fundamental pillar of sustainable development; however, the sustainable vision goes beyond traditional quantitative growth toward balanced qualitative growth that considers rational use of natural resources. This dimension requires developing environmentally friendly economic sectors, diversifying income sources, creating green jobs, and encouraging innovation and clean technology. It also requires adopting alternative economic approaches such as the circular economy, which recycles resources and reduces waste, and the blue economy, which invests in seas and oceans without destroying them.

- **Social dimension:** Sustainability cannot be achieved without social justice. The primary objective of this dimension is to ensure equal opportunities and improve quality of life for all segments of society. This includes combating poverty, expanding basic services (health, education, housing), reducing social and spatial disparities, and enhancing community participation in decision-making. This dimension is strongly linked to the concept of environmental justice, meaning ensuring that vulnerable groups do not bear the greatest burden of environmental damage.

- **Environmental dimension:** This dimension constitutes the core of sustainable development, aiming to protect ecosystems and ensure rational and renewable use of natural resources (water, forests, land, energy). It is based on principles such as pollution prevention rather than treatment, biodiversity as a strategic asset, and recognition of the planet's limited capacities. It also requires policies to mitigate climate change impacts, transition to renewable energy, and sustainable planning of cities and urban spaces.

- **Cultural dimension:** Although early literature on sustainable development focused mainly on economic, environmental, and social dimensions, a fourth dimension has gradually asserted itself: the cultural dimension. This means that development cannot be achieved in isolation from peoples' cultural identity, and that tangible and intangible heritage constitutes a fundamental resource for development. Preserving language, customs, and local values, and valorizing architectural and artistic heritage, represent a central element in achieving balanced development that respects cultural specificities in the era of globalization.

- **Governance dimension:** Achieving sustainability is no longer possible without good governance that establishes effective, accountable, and inclusive institutions. The 2030 Agenda has enshrined this dimension through Goal 16, which explicitly links peace, justice, and strong institutions to progress toward the other goals, making governance a horizontal enabler that affects economic, social, environmental, and cultural dimensions alike (Mansour, 2019, p. 45).

Second: Core Pillars of Sustainable Development
This analysis shows that sustainable development is a comprehensive civilizational project requiring integrated interaction among economic, social, environmental, and cultural dimensions within a long-term perspective that

balances present interests and future rights. Its main pillars are (Abu Zaid, 2017, p. 90):

- Rule of law, accountability, and transparency: reducing corruption and enhancing access to information and grievance mechanisms, thereby improving public spending efficiency and development outcomes;
- Participation and social inclusion: involving citizens, civil society, and the private sector in planning, implementation, and evaluation as a condition for building policy legitimacy and sustainability, according to United Nations governance programs;
- Policy coherence across levels: aligning sectoral policies and preventing contradictions among them, especially through local governments, in line with OECD recommendations that formulated practical principles to enhance coherence between national and local levels;
- A human rights-based approach: linking sustainability goals to existing human rights obligations, whereby most goal indicators intersect with human rights commitments, improving monitoring, evaluation, and targeting.

3. Ecotourism in Light of Technological Innovation and Artificial Intelligence:

In light of the foregoing theoretical grounding of ecotourism and sustainable development concepts, it is clear that maintaining balance between tourism activity and the environment is no longer possible through traditional methods, but rather requires the use of modern tools based on innovation and artificial intelligence. Technological development has provided new possibilities for managing environmental resources, analyzing data, and guiding tourist behavior toward sustainability. From this perspective, this section addresses the most important leading international experiences that have integrated artificial intelligence into their ecotourism systems, with the aim of drawing lessons that can be employed to support sustainable tourism in Algeria (United Nations World Tourism Organization, 2022, p. 26).

3.1. Digital Transformation in the Tourism Industry:

Over the past two decades, the tourism sector has witnessed a radical transformation due to the digital revolution, which profoundly changed patterns of tourism production and consumption. Electronic platforms such as Booking.com, TripAdvisor, and Airbnb have become key tools in booking tourism services and exchanging evaluations and information, making big data one of the most important elements of decision-making in tourism planning.

This digital transformation has not only affected consumer behavior, but also changed the management system of tourist destinations, as it has become possible to analyze visitor flows, identify preferences, and accurately forecast demand. The concept of smart tourism represents an advanced stage of this transformation, as smart destinations rely on integrating technology, artificial intelligence, and the Internet of Things in managing facilities and services, enhancing operational efficiency and preserving environmental resources (Gretzel, 2021, p. 03).

These transformations contribute to reducing waste in energy and water, improving tourist mobility, and enhancing effective communication between

visitors and local communities, making digital transformation a fundamental pillar for achieving sustainability in the tourism sector.

First: The Role of Artificial Intelligence in Supporting Environmental Sustainability

Artificial intelligence (AI) represents a strategic tool for developing sustainable tourism practices, as it enables the analysis of massive amounts of environmental data in real time, helping to predict the impacts of tourism activity on the environment and develop more effective preventive policies. Many destinations today use AI algorithms to monitor natural resource consumption and carbon emissions, and to regulate environmental carrying capacity, thereby reducing pressure on sensitive ecosystems.

For example, smart hotels in some European countries rely on automated control systems that regulate electricity and water consumption according to room occupancy, leading to waste reduction exceeding 20%. Tourism travel applications also employ AI recommendation systems to guide tourists toward environmentally friendly activities such as non-polluting trips or staying in certified green facilities.

Thus, artificial intelligence has become a key lever for achieving digital environmental governance that contributes to reducing the negative impact of tourism on the environment and enhancing energy efficiency in tourism value chains (Ibrahim, 2023, p. 155).

Second: Tourism Innovation as a Tool for Green Development

Tourism innovation is not limited to technological advancement alone; it also includes innovating economic and administrative models that support the transition toward a green tourism economy. Innovative tourism institutions no longer suffice with improving services, but seek to redesign their operations according to the principles of the circular economy, which is based on reuse, waste reduction, and maximizing value from natural resources. In this context, the concept of social innovation in tourism emerges, encouraging the involvement of local communities in managing environmental projects and offering authentic tourism products, creating added economic and social value simultaneously. Innovation in marketing and promotion systems, through digital platforms and virtual reality, also allows highlighting the environmental identity of destinations and enhancing global awareness of responsible tourism.

Accordingly, tourism innovation represents a strategic tool for achieving green development by integrating technology, social responsibility, and economic creativity into a single integrated model that balances profitability and environmental conservation (OECD, 2023, p. 52).

4. Leading International Experiences in Using Artificial Intelligence and Tourism Innovation to Serve Ecotourism:

Global tourism has witnessed major transformations thanks to artificial intelligence and technological innovation, providing new opportunities to achieve environmental sustainability. Among the leading experiences in this field are the Emirati and Spanish experiences, which represent two distinguished models in employing technology to serve sustainable ecotourism.

4.1. The Experience of the United Arab Emirates:
The United Arab Emirates is considered one of the most prominent Arab models that have succeeded in integrating the principles of innovation and artificial intelligence into their tourism strategies to achieve environmental sustainability goals. The state early adopted a vision based on transitioning toward smart tourism by investing in digital infrastructure and sustainable environmental projects that balance economic development and the protection of natural resources.

The UAE launched qualitative initiatives such as the "UAE Artificial Intelligence Strategy 2031," which aims to employ artificial intelligence in vital sectors, including tourism and the environment. The Ministry of Economy also adopted within the "Tourism Strategy 2031" the principle of "smart green tourism," by encouraging tourism establishments to reduce energy and water consumption by 25% by 2030.

In the field of ecotourism, the Dubai Desert Conservation Reserve and Al Marmoom Reserve are considered pioneering applied models for integrating technology into biodiversity protection. Smart monitoring systems based on artificial intelligence and the Internet of Things have been adopted to track the movement of animals and plants and regulate tourism activities according to ecosystem carrying capacity. Digital applications have also been created that allow tourists to learn about smart ecological trails through augmented reality (AR) technologies, enhancing environmental awareness and positive interaction with nature.

The strength of the Emirati experience is reflected in its focus on innovation in tourism services, such as smart hotels holding global LEED sustainability certifications, and sustainable transport systems such as electric and aerial vehicles used in some tourist destinations. The World Tourism Organization has classified the UAE among the most advanced Arab destinations in smart and sustainable tourism, thanks to its successful integration of technology and environmental awareness (Ben Dineidina & Salem, 2024, p. 120).

4.2. The Spanish Experience:
Spain represents an advanced model in linking tourism innovation with artificial intelligence on the one hand, and with sustainable ecotourism on the other. In this context, Spanish national policy presents the "Plan for the Modernization and Competitiveness of the Tourism Sector 2021–2023," which emphasizes digitalization and artificial intelligence as a driving force toward a more sustainable and competitive tourism model, with a focus on developing the "Destination Intelligence" system and investing in new technologies for destination management.

At the level of practical application, projects such as Spain Living Lab (2024–2026) stand out, as they work on deploying intelligent agents, analyzing visitors' behavioral data, and using technologies such as digital twins at heritage and natural sites. This enhances the ability to manage visitor flows, mitigate environmental impact, and improve the ecotourism experience. With regard to tourist destinations, the SEGITTUR platform has been employed to manage open

tourism data and facilitate its exchange between public and private entities, with the aim of improving knowledge of visitor patterns, managing environmental impact, and using resources more effectively. It is noted that the platform supports integration and tourism intelligence, and improves environmental impact through data analysis and technological solutions. Spain's experience can be considered a successful example of AI-supported tourism innovation, as it supports the transition toward a sustainable ecotourism model, provided that an open digital institutional infrastructure is available, along with targeted investments and cooperation between the public and private sectors, with particular orientation toward less pressured natural and heritage destinations. This model can be relied upon as a reference for emerging international experiences (EU Transition Pathways, 2022, p. 10).

From an ecotourism perspective in particular, these experiences provide evidence that digital technologies and artificial intelligence can contribute to directing visitors toward less crowded routes, thereby protecting sensitive ecosystems, in addition to measuring the resource footprint (energy, water) in natural and heritage destinations, as well as simulating scenarios of exposure to tourism pressure or climate change (through digital twins) before they occur. This enhances response capacity and sustainability. For example, the digital twin project of the Alhambra Palace in Granada represents a practical example of how technology can support the preservation of heritage and ecosystems within the operation of a high-density tourist destination.

3.4. The Reality and Strategies of Algeria in the Field of Tourism Innovation and Artificial Intelligence to Support Sustainable Ecotourism
Although ecotourism in Algeria is still in a growth phase, the state has in recent years begun to adopt a strategic vision aimed at integrating technology and innovation into the tourism system in order to achieve environmental and economic sustainability. The national tourism strategy "Destination Algeria 2030" indicates that digital transformation and innovation constitute two fundamental pillars for developing a competitive and sustainable tourism sector, based on the valorization of the diverse natural and cultural assets with which the country abounds, from the Sahara Desert and oases to Mediterranean coasts and mountain forests.

In this framework, the Ministry of Tourism and Traditional Crafts has launched a series of digital programs and projects, most notably the national digital tourism promotion platform project (Visit Algeria), which aims to improve the quality of tourism information, facilitate communication between visitors and tourism institutions, and enhance the environmental image of Algerian destinations. Startups in the tourism sector have also been encouraged to develop smart applications that contribute to the management of ecotourism destinations, within the digital transformation initiative of the tourism sector in cooperation with the Ministry of the Knowledge Economy and Startups.

From an environmental perspective, Algeria has incorporated principles of the green economy and renewable energy into its tourism policy, particularly by encouraging eco-lodge projects in the south and mountainous regions, and developing sustainable desert tourism that takes into account the carrying

capacity of ecosystems. Efforts are also underway to build qualified human capital capable of employing technology in the service of the environment and society.

Integrating artificial intelligence and tourism innovation into the Algerian tourism system will enable improved resource management, guide tourist behavior toward sustainable practices, and achieve a balance between economic profitability and environmental preservation.

Thus, it can be said that Algeria, thanks to its geographical location and environmental diversity, is capable of becoming a leading destination for smart ecotourism in Africa and the Arab world, provided that a comprehensive national vision based on innovation, digital environmental governance, and partnership between the public and private sectors is adopted.

2.5. Recommendations:
In light of these lessons, Algeria can benefit from these international experiences to develop a national model for smart ecotourism that takes into account its environmental and social specificities. Algeria possesses vast natural wealth that includes deserts, forests, coasts, and oases, making it fertile ground for the application of sustainable tourism projects supported by artificial intelligence.
The need emerges to:
• Launch a national digital platform for ecotourism that links the ministries of tourism, environment, culture, and interior, in order to exchange real-time data on visitor flows and their environmental impacts.
• Encourage emerging tourism enterprises to develop digital applications to promote natural and cultural sites in a responsible and sustainable manner.
• Activate international partnerships with organizations such as UNWTO and OECD to benefit from experiences in environmental digitalization and green transition.

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